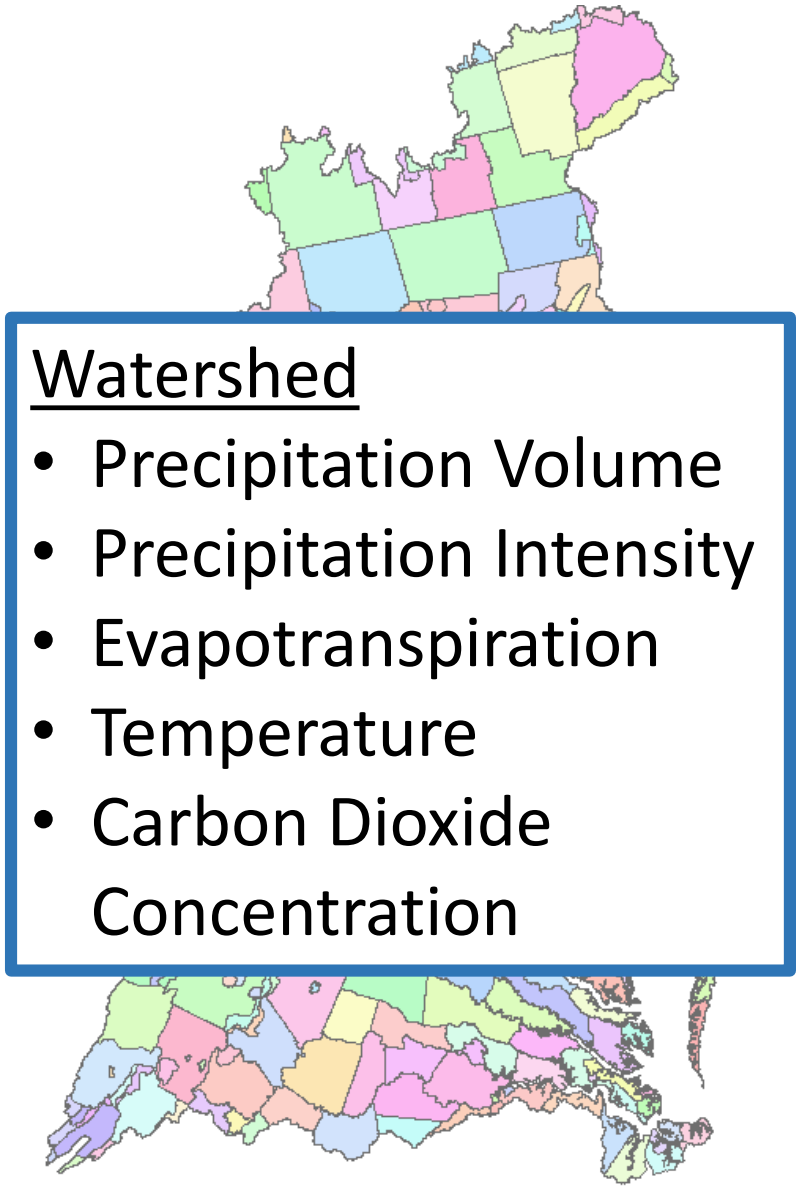
CBP Watershed Climate Efforts

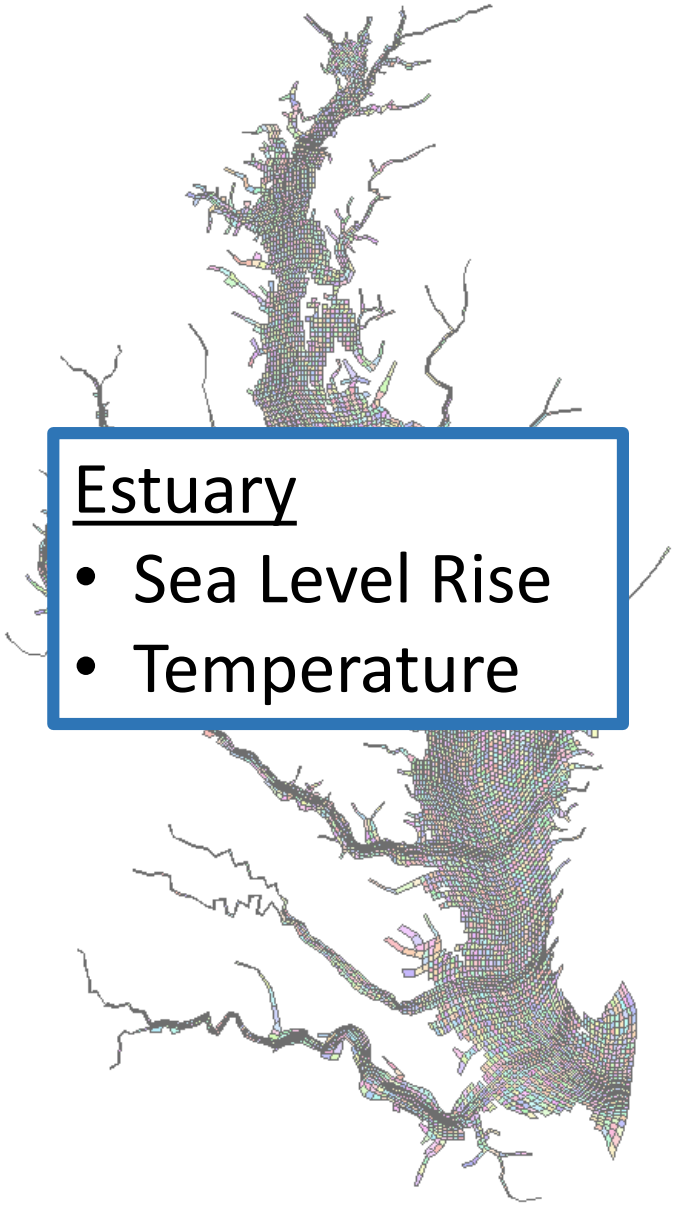
Kyle Hinson, Gopal Bhatt, Andrew Sommerlot, Lewis Linker, Gary Shenk

Climate Modification Inputs



Watershed

- Precipitation Volume
- Precipitation Intensity
- Evapotranspiration
- Temperature
- Carbon Dioxide Concentration

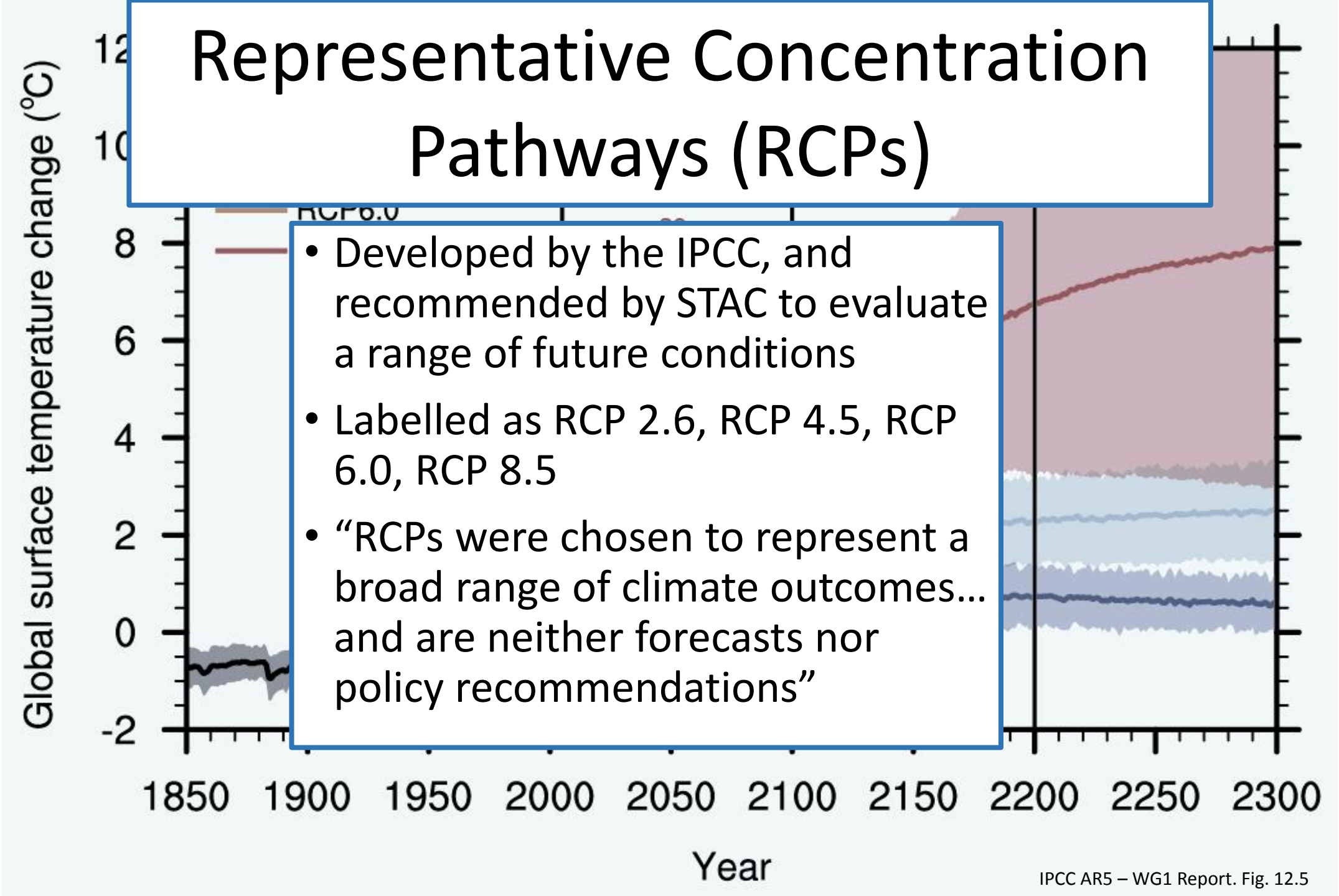


Estuary

- Sea Level Rise
- Temperature

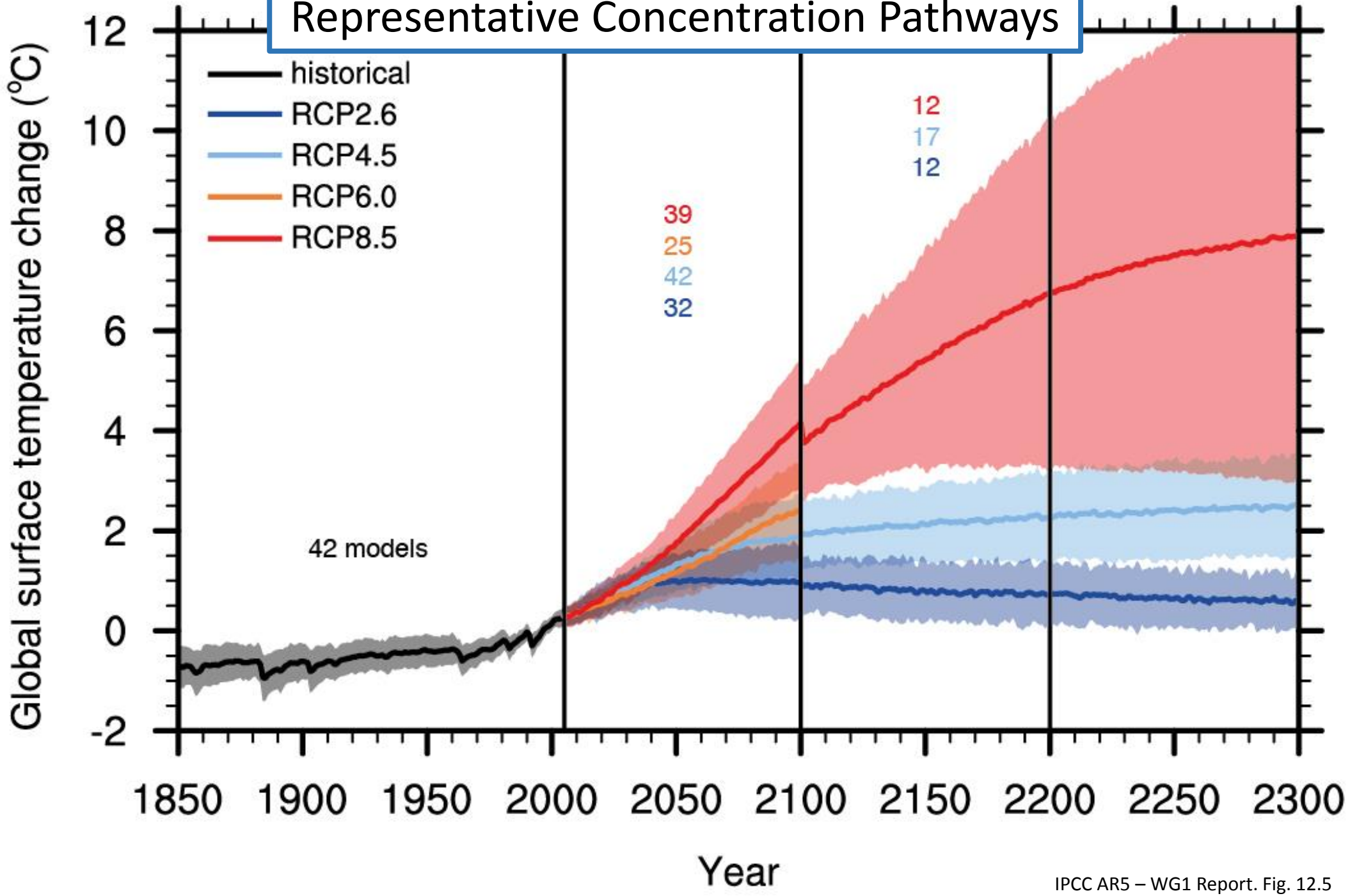
Representative Concentration Pathways (RCPs)

- Developed by the IPCC, and recommended by STAC to evaluate a range of future conditions
- Labelled as RCP 2.6, RCP 4.5, RCP 6.0, RCP 8.5
- “RCPs were chosen to represent a broad range of climate outcomes… and are neither forecasts nor policy recommendations”



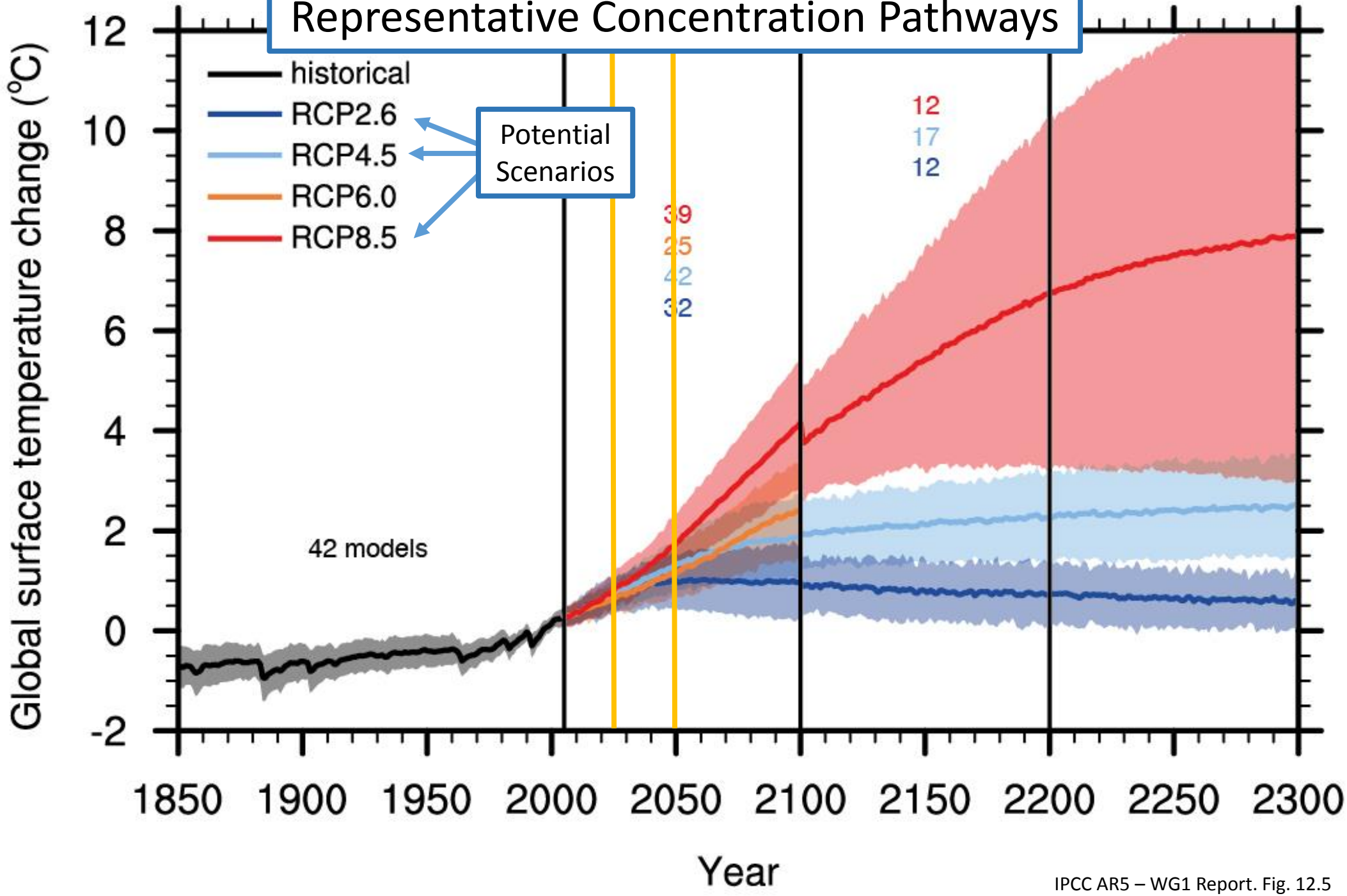
IPCC AR5 – WG1 Report. Fig. 12.5

Representative Concentration Pathways

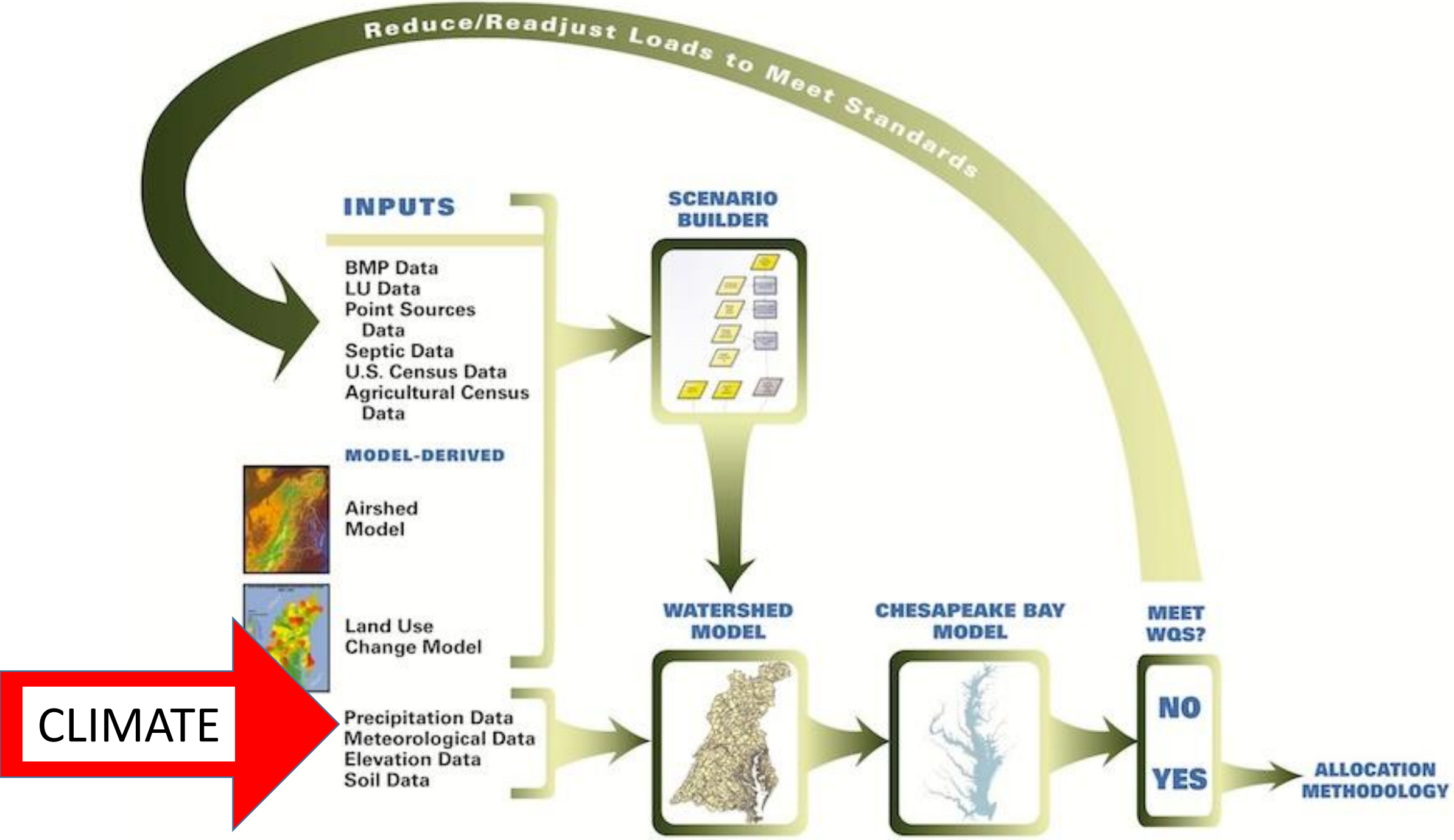


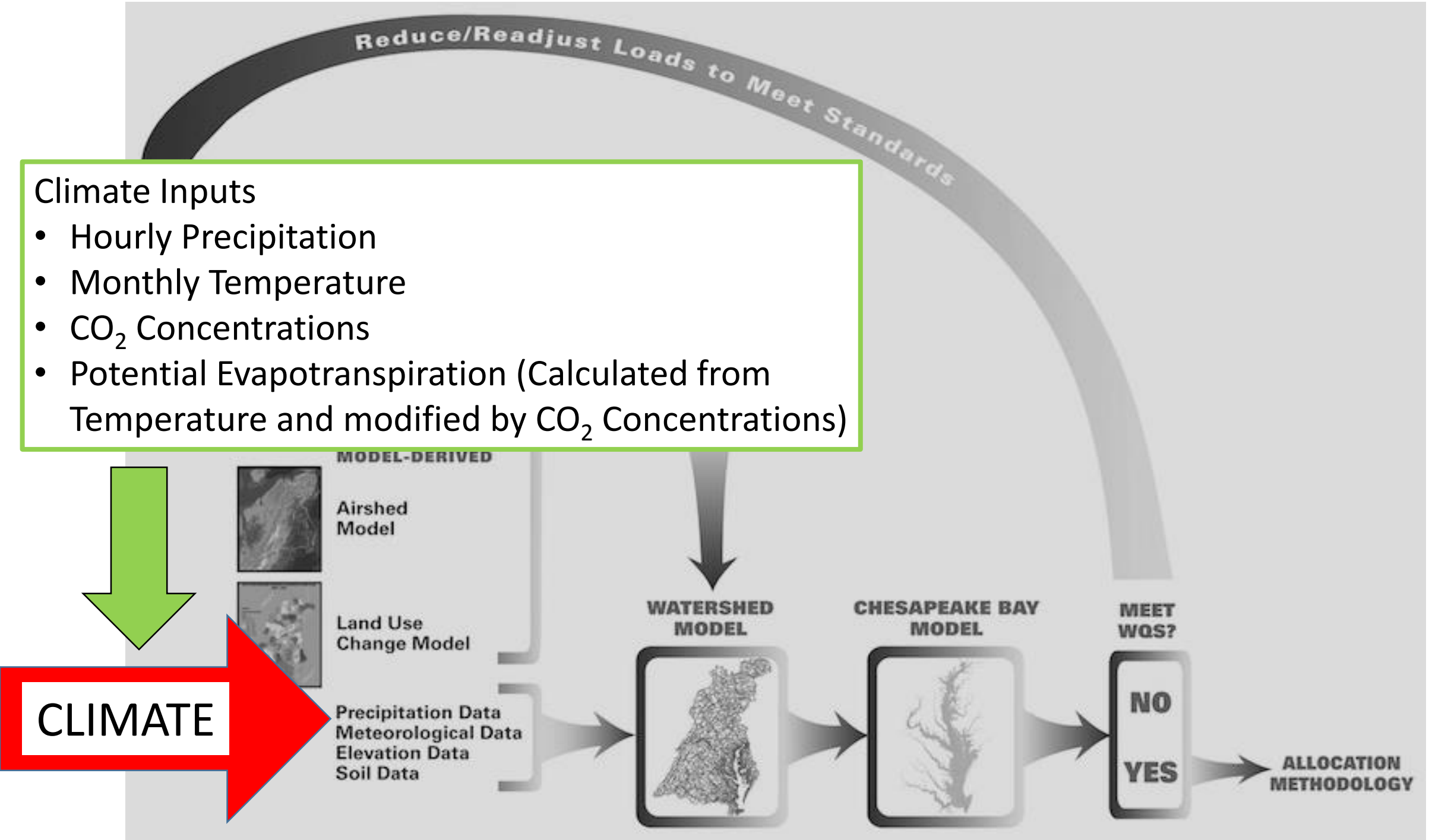
IPCC AR5 – WG1 Report. Fig. 12.5

Representative Concentration Pathways



IPCC AR5 – WG1 Report. Fig. 12.5


Reduce/Readjust Loads to Meet Standards
INPUTS
BMP Data
LU Data
Point Sources Data
Septic Data
U.S. Census Data
Agricultural Census Data
MODEL-DERIVED
Airshed Model
Land Use Change Model
Precipitation Data
Meteorological Data
Elevation Data
Soil Data
SCENARIO BUILDER
WATERSHED MODEL
CHESAPEAKE BAY MODEL
MEET WQS?
NO
YES
ALLOCATION METHODOLOGY
CLIMATE



Climate Inputs

- Hourly Precipitation
- Monthly Temperature
- CO_2 Concentrations
- Potential Evapotranspiration (Calculated from Temperature and modified by CO_2 Concentrations)

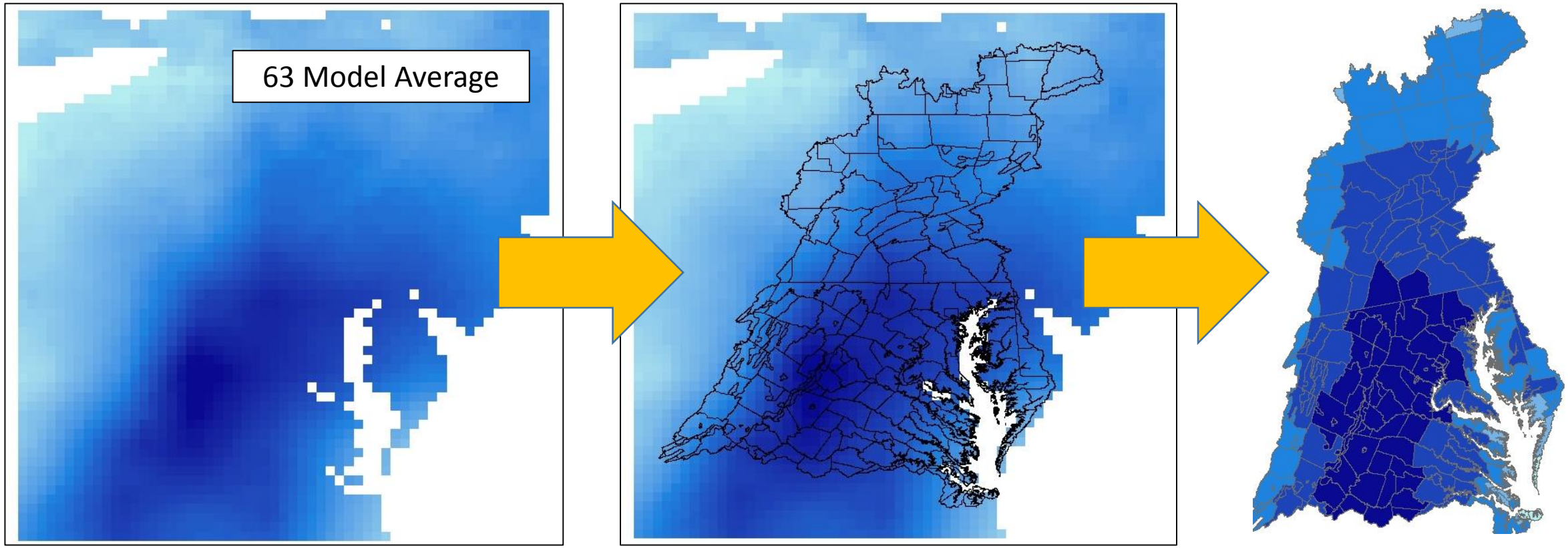
Climate Input Options

- Δ Approach – Historical compared to Projected Run
  - Good, Simple, Intuitive
  - Harder to capture changes in variability
- Use Median/Mean Downscaled Projecti
  - Better captures changes in s
  - Changes in
  - Need to cho onally (possible to use a variation of approach)
  - Significant ti ed – calibration of historical forcing run before future projection run

WINNER!

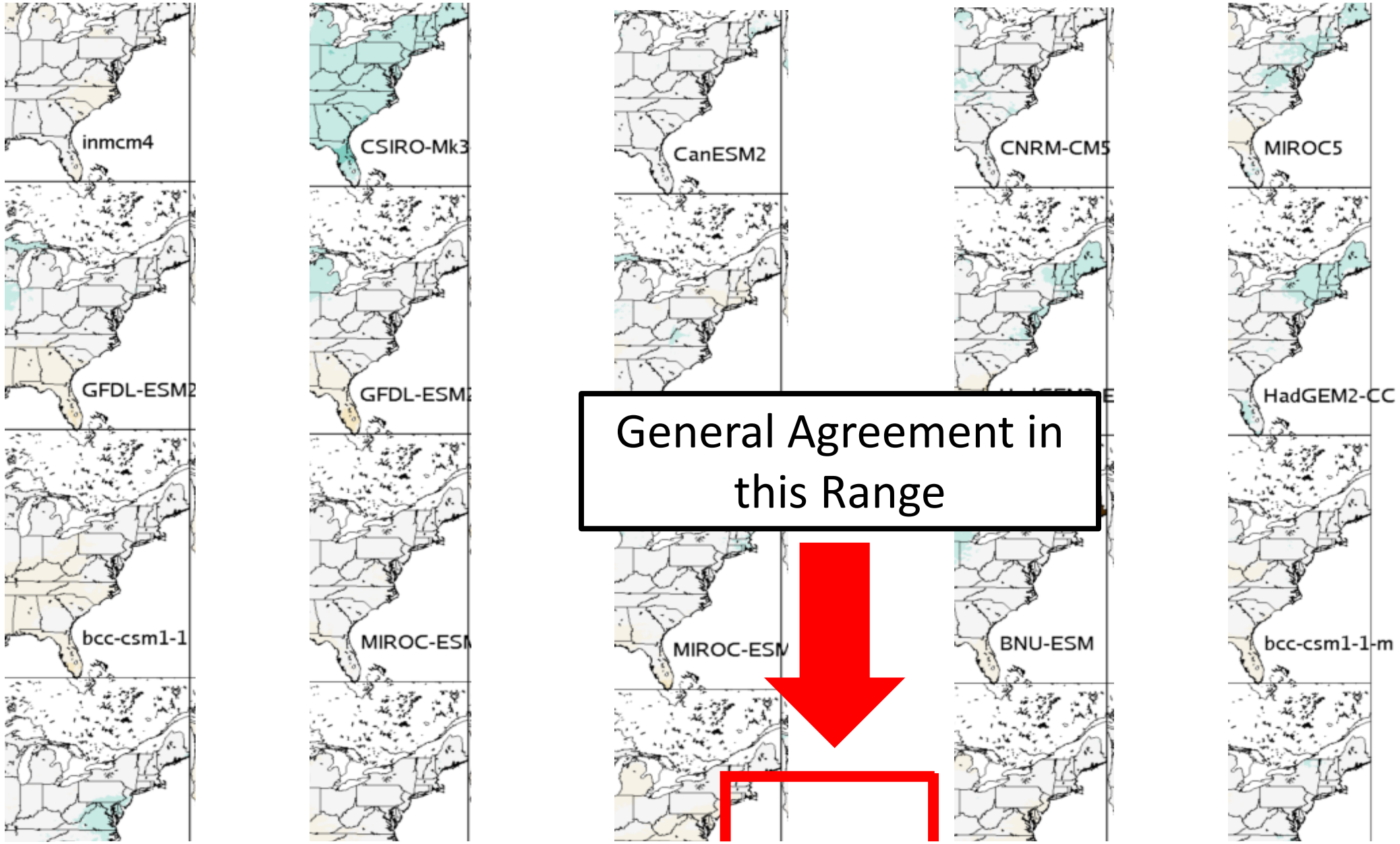
Climate Models

- An ensemble comprised of 63 General Circulation Models (GCMs) was created in this analysis
- These GCMs were statistically downscaled using a Bias-Corrected Spatial Disaggregation (BCSD) method at a resolution of 1/8° latitude-longitude (approx. 12 km)



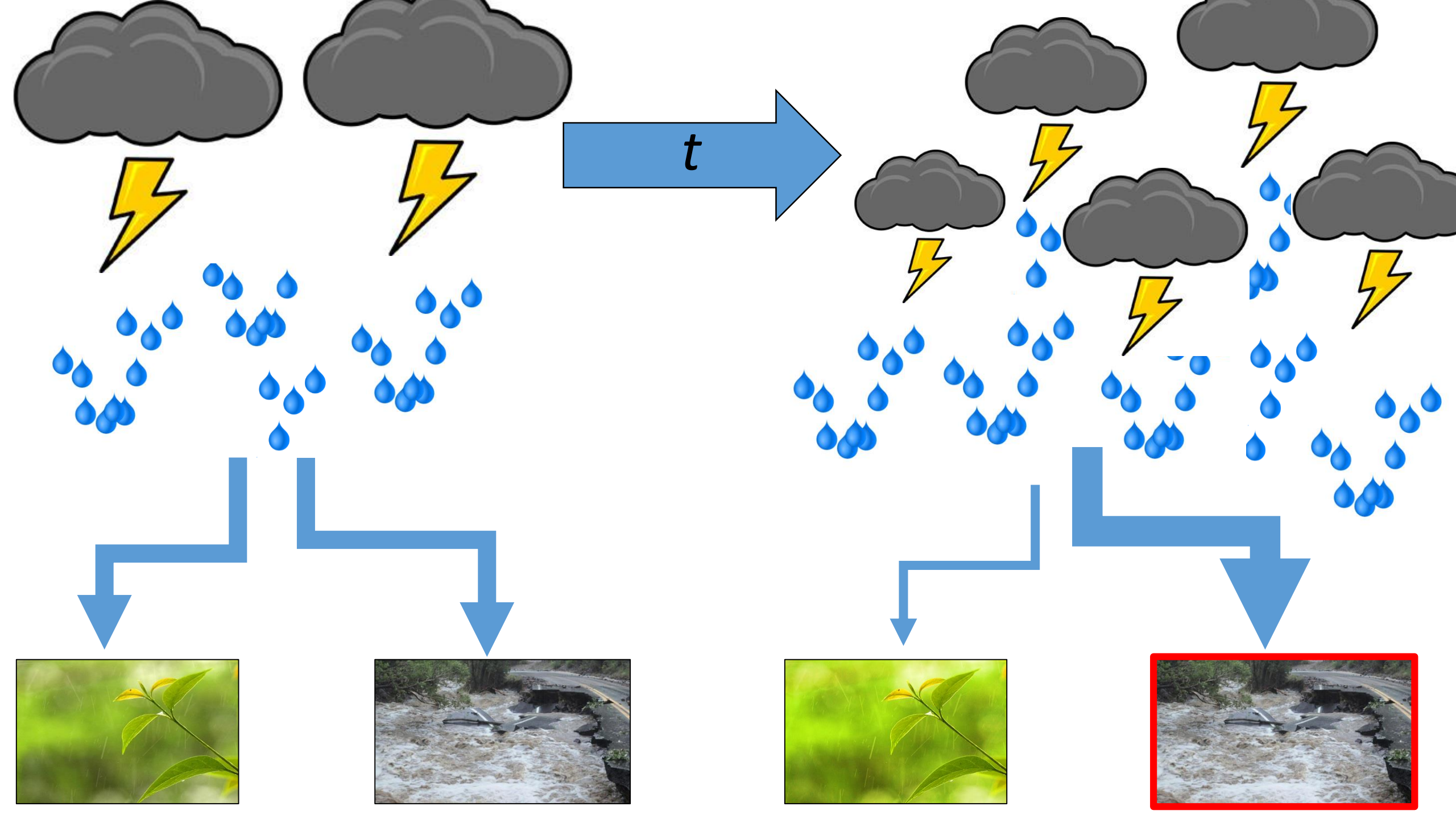
Δ Precipitation Annual 2040-2069 vs. 1971-2000, RCP4.5: Units=% Change

MACA Comparison



BCSD vs. MACA – back of the envelope

Watershed Average	RCP 4.5 BCSD	RCP 4.5 MACA	RCP 8.5 BCSD	RCP 8.5 MACA
2025 Temperature	+1.05 °C	+1.38 °C	+1.16 °C	+1.49 °C
2025 Precipitation	Calculated with PRISM	+52.07 mm	Calculated with PRISM	+48.26 mm
2050 Temperature	+2.08 °C	+2.38 °C	+2.65 °C	+3.18 °C
2050 Precipitation	+75.81 mm	+67.56 mm	+77.91 mm	+77.98 mm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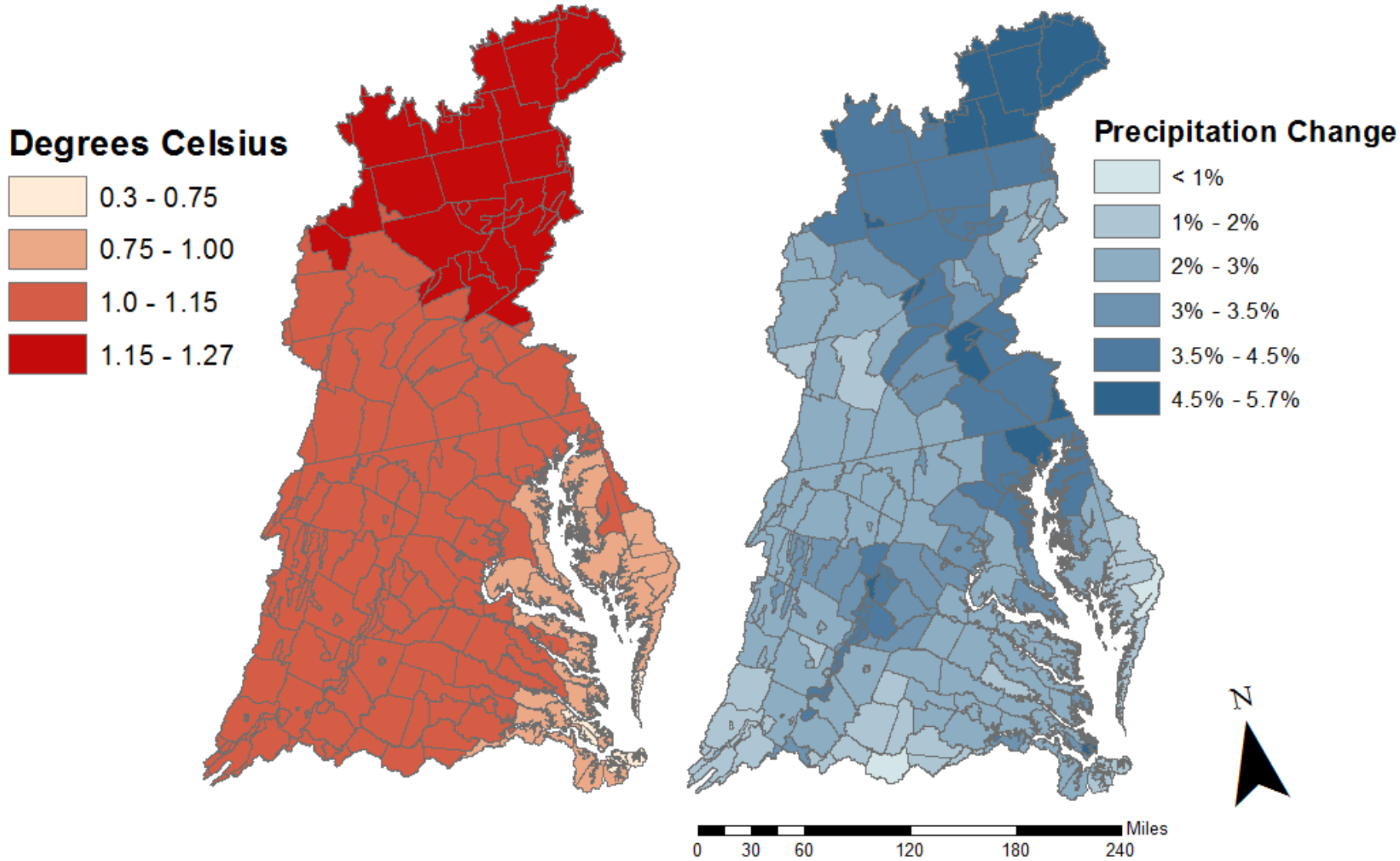
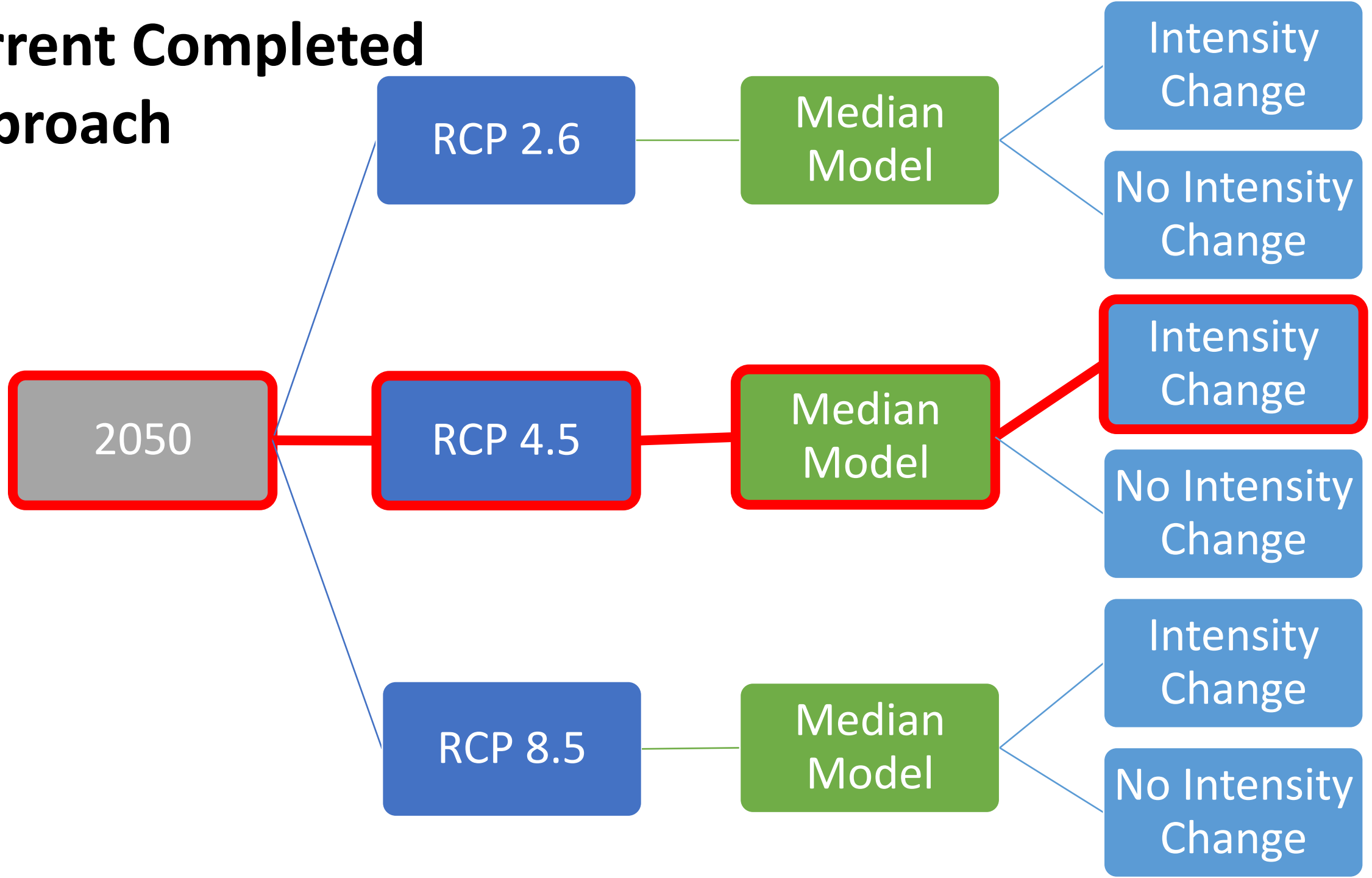
Current Completed Approach

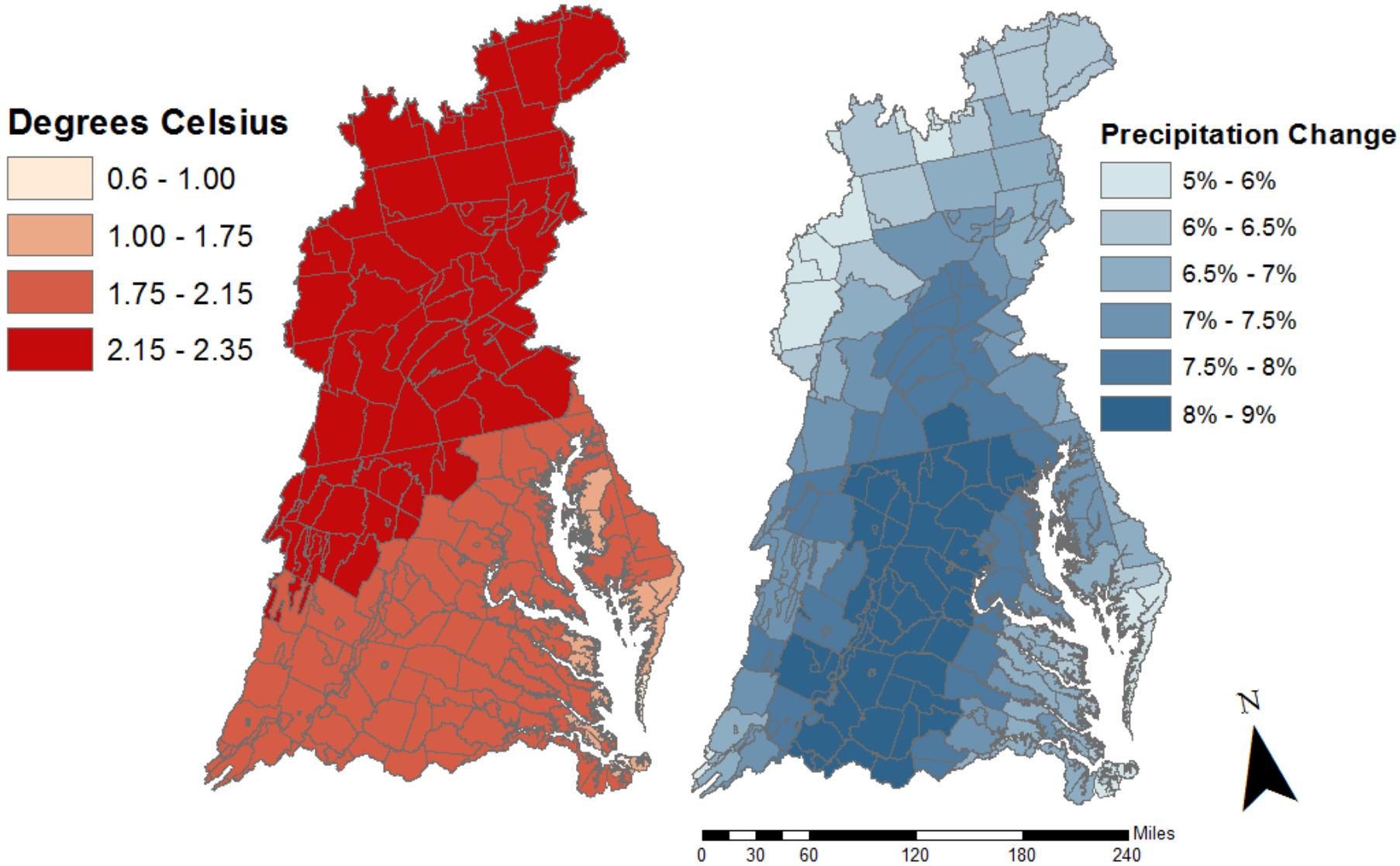
CB Watershed 2025
Changes in Temperature and Precipitation

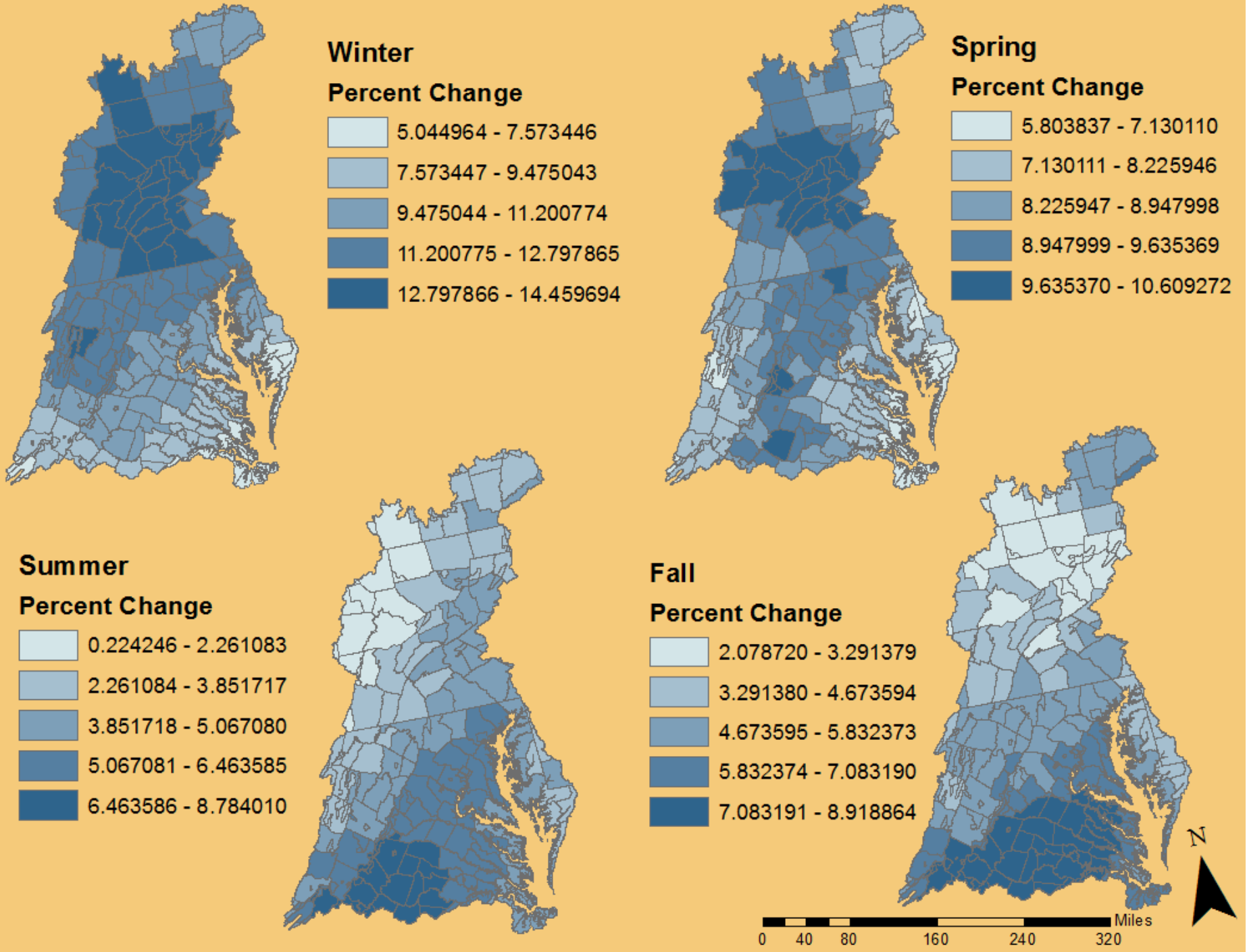


Current Completed Approach



CB Watershed 2050
Changes in Temperature and Precipitation




Winter
Percent Change
5.044964 - 7.573446
7.573447 - 9.475043
9.475044 - 11.200774
11.200775 - 12.797865
12.797866 - 14.459694
Spring
Percent Change
5.803837 - 7.130110
7.130111 - 8.225946
8.225947 - 8.947998
8.947999 - 9.635369
9.635370 - 10.609272
Summer
Percent Change
0.224246 - 2.261083
2.261084 - 3.851717
3.851718 - 5.067080
5.067081 - 6.463585
6.463586 - 8.784010
Fall
Percent Change
2.078720 - 3.291379
3.291380 - 4.673594
4.673595 - 5.832373
5.832374 - 7.083190
7.083191 - 8.918864
N
Miles
0 40 80 160 240 320

Questions?

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Image by Alan Kennedy, University of Bristol, 2016

Citations

- CMIP5 Dataset
  - We acknowledge the World Climate Research Programme's Working Group on Coupled Modelling, which is responsible for CMIP, and we thank the climate modeling groups (listed on slide XX of this presentation) for producing and making available their model output. For CMIP the U.S. Department of Energy's Program for Climate Model Diagnosis and Intercomparison provides coordinating support and led development of software infrastructure in partnership with the Global Organization for Earth System Science Portals.
- BCSD Downscaled Climate Data:
  - Reclamation, 2013. 'Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections: Release of Downscaled CMIP5 Climate Projections, Comparison with preceding Information, and Summary of User Needs', prepared by the U.S. Department of the Interior, Bureau of Reclamation, Technical Services Center, Denver, Colorado. 47pp.

Citations, contd.

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- Meinshausen, Malte, et al. "The RCP greenhouse gas concentrations and their extensions from 1765 to 2300." *Climatic change* 109.1-2 (2011): 213-241.
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- Ning, Liang, Emily E. Riddle, and Raymond S. Bradley. "Projected changes in climate extremes over the northeastern United States*." *Journal of Climate* 28.8 (2015): 3289-3310.
- Socolofsky, Scott, E. Eric Adams, and Dara Entekhabi. "Disaggregation of daily rainfall for continuous watershed modeling." *Journal of Hydrologic Engineering* 6.4 (2001): 300-309.

Modeling Center (or Group)	Institute ID	Model Name
Commonwealth Scientific and Industrial Research Organization (CSIRO) and Bureau of Meteorology (BOM), Australia	CSIRO-BOM	ACCESS1.0 ACCESS1.3
Beijing Climate Center, China Meteorological Administration	BCC	BCC-CSM1.1 BCC-CSM1.1(m)
Instituto Nacional de Pesquisas Espaciais (National Institute for Space Research)	INPE	BESM OA 2.3
Canadian Centre for Climate Modelling and Analysis	CCCMA	CanESM2 CanCM4 CanAM4
University of Miami - RSMAS	RSMAS	CCSM4(RSMAS)*
National Center for Atmospheric Research	NCAR	CCSM4
Community Earth System Model Contributors	NSF-DOE-NCAR	CESM1(BGC) CESM1(CAM5) CESM1(CAM5.1,FV2) CESM1(FASTCHEM) CESM1(WACCM)
Center for Ocean-Land-Atmosphere Studies and National Centers for Environmental Prediction	COLA and NCEP	CFSv2-2011
Centro Euro-Mediterraneo per I Cambiamenti Climatici	CMCC	CMCC-CESM CMCC-CM CMCC-CMS
Centre National de Recherches Météorologiques / Centre Européen de Recherche et Formation Avancée en Calcul Scientifique	CNRM-CERFACS	CNRM-CM5
		CNRM-CM5-2
Commonwealth Scientific and Industrial Research Organization in collaboration with Queensland Climate Change Centre of Excellence	CSIRO-QCCCE	CSIRO-Mk3.6.0
EC-EARTH consortium	EC-EARTH	EC-EARTH
LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences and CESS,Tsinghua University	LASG-CESS	FGOALS-g2
Meteorological Research Institute	MRI	MRI-CGCM3
Norwegian Climate Centre	NCC	NorESM1-M NorESM1-ME

Modeling Center (or Group)	Institute ID	Model Name
LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences	LASG-IAP	FGOALS-gl FGOALS-s2
The First Institute of Oceanography, SOA, China	FIO	FIO-ESM
NASA Global Modeling and Assimilation Office	NASA GMAO	GEOS-5
NOAA Geophysical Fluid Dynamics Laboratory	NOAA GFDL	GFDL-CM2.1 GFDL-CM3 GFDL-ESM2G GFDL-ESM2M GFDL-HIRAM-C180 GFDL-HIRAM-C360
NASA Goddard Institute for Space Studies	NASA GISS	GISS-E2-R GISS-E2-R-CC
National Institute of Meteorological Research/Korea Meteorological Administration	NIMR/KMA	HadGEM2-AO
Met Office Hadley Centre (additional HadGEM2-ES realizations contributed by Instituto Nacional de Pesquisas Espaciais)	MOHC (additional realizations by INPE)	HadCM3 HadGEM2-CC HadGEM2-ES HadGEM2-A
Institute for Numerical Mathematics	INM	INM-CM4
Institut Pierre-Simon Laplace	IPSL	IPSL-CM5A-LR IPSL-CM5A-MR IPSL-CM5B-LR
Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies	MIROC	MIROC-ESM MIROC-ESM-CHEM
Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	MIROC	MIROC4h MIROC5
Max-Planck-Institut für Meteorologie (Max Planck Institute for Meteorology)	MPI-M	MPI-ESM-MR MPI-ESM-LR MPI-ESM-P